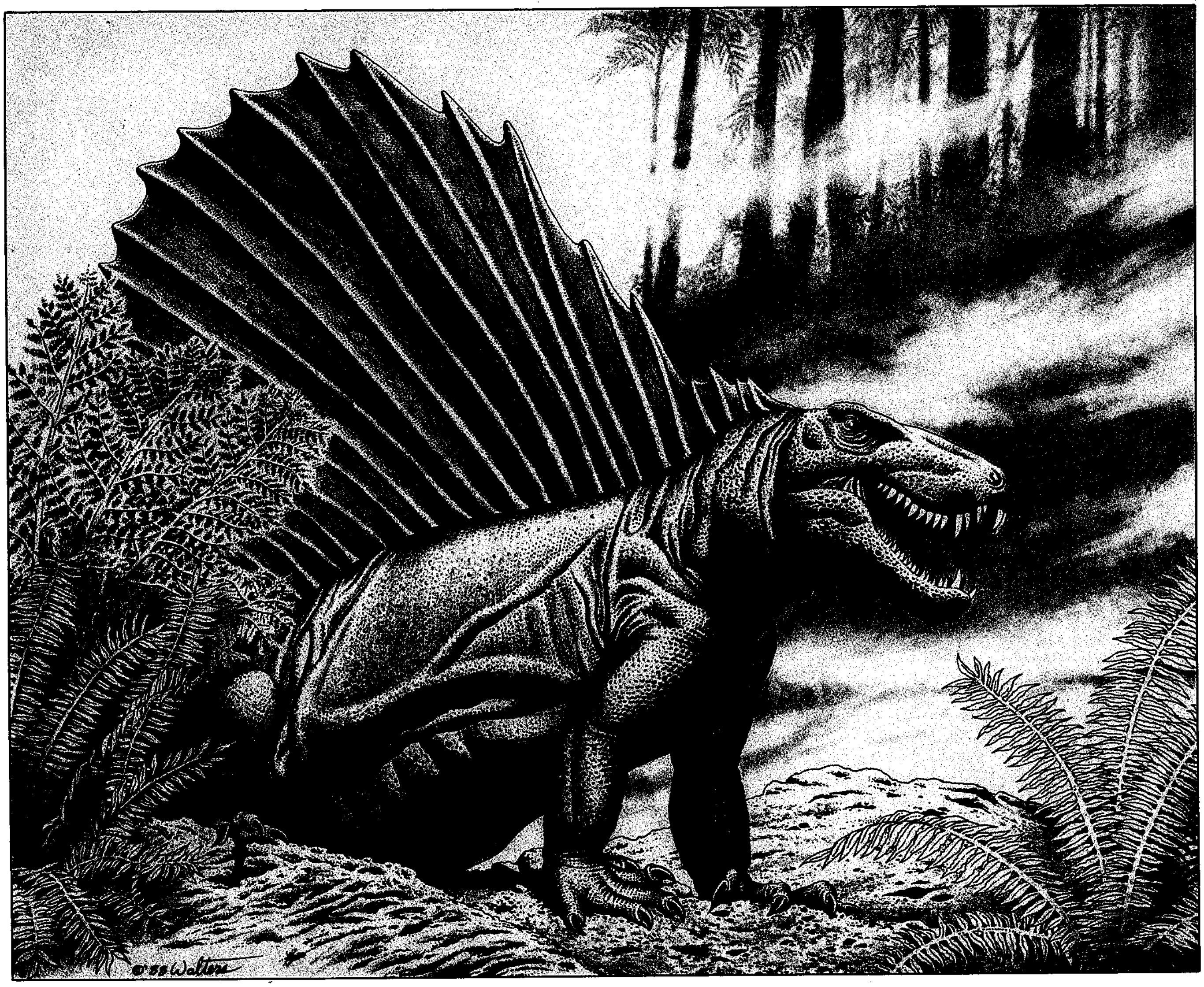
THE MOSASAUR



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The Mosasaur

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Medial Cretaceous Carnivorous Dinosaur and Footprints from New Jersey

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Museum of Natural History, Princeton University[1]

Abstract

The earliest Cretaceous dinosaur remains known from New Jersey consist of a partial metatarsal from a clay of Potomac or Raritan or Magothy age (Cenomanian to Santonian) at Roebling, Burlington County, and some trackways in the Woodbridge Clay Member of the Raritan Formation (Cenomanian) at Woodbridge, Middlesex County. The bone belongs to a carnosaur of uncertain genus and family. The footprints--which are the only Cretaceous dinosaur tracks known from eastern North America--are also attributed to a carnosaur. They represent a morphotype to which such names as *Irenesauripus*, *Satapliasaurus*, *Bueckeburgichnus*, and *Megalosauropus* have been applied.

Introduction

Dinosaur remains of Late Cretaceous (Campanian and Maastrichtian) age are not uncommon in New Jersey, and their study or restudy is an ongoing project (e.g., Baird & Horner, 1977; Horner, 1979; Gallagher et al., 1986; Baird, 1986). On the other hand, the significantly earlier dinosaurian record of the Cenomanian through Santonian Stages--what might be called the Medial Cretaceous although the period legally has no Middle--is extremely meager, and has never been formally described. That record comprises only two finds: a broken metatarsal of a carnosaur that was collected at Roebling, Burlington County, sometime in the late 19th or early 20th century, and some evidently carnosaurian trackways that were exposed in a claypit at Woodbridge, Middlesex County, in 1929 and 1930 (Fig. 1). To document these occurrences is the purpose of this paper. As the sequel will show, the research has involved history as much as prehistory.

I. The Carnosaur from Roebling, New Jersey

The distal end of a metatarsal (PU 16760) turned up in the Princeton "greensand" collection; it now belongs to the Peabody Museum of Yale University. The accompanying label, in the handwriting of Dr. William J. Sinclair, states only, "From the clay at Roebling, N.J., from Dr. C. C. Abbott." Although no date of collection or acquisition is given, the museum received archaeological material from Abbott in 1911 and 1916; Sinclair was at Princeton from 1904 until his death in 1935. Dr. Charles Conrad Abbott (1843-1919) was a pioneer of New Jersey archaeology who belonged to the State Geological Survey in 1865 and whose lifelong home was "Three Beeches," a farm on the Delaware River about eight miles upstream from Roebling (Aiello, 1967). How long Dr. Abbott may have owned the bone before donating it to Princeton is beyond conjecture.

Roebling, Burlington County, is on the south bank of the Delaware, due south of Trenton and southwest of Bordentown. It lies in the northeastern corner of the Bristol quadrangle (Owens & Minard, 1964) at latitude 40°06'43" N, longitude 74°47' W. Along this stretch of the Delaware ceramic clays of Cretaceous and Pleistocene ages have long been dug commercially, and in such a claypit the dinosaur bone was undoubtedly found. No identifying matrix adheres to the specimen but its lumen has a thin lining of crystalline marcasite that is consistent with an origin in one of the Cretaceous clay beds. The bone is uncrushed, unweathered, and in pristine condition.

Stratigraphy.

"From the clay at Roebling" is stratigraphically equivocal, as two clay-bearing formations are mapped by Owens & Minard (1964) as occurring along the river in the Roebling area: the Delaware Valley "Raritan" and the overlying Magothy Formation. Without knowing the exact location of the claypit and the level within the pit we cannot be sure which was the source formation. Our most detailed information on the New Jersey clay industry in the period when the dinosaur bone was probably col-

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lected is the 1904 report by Ries et al., which of course must be interpreted in the light of more recent studies (for example, they used the term Raritan to include what is now identified as the Magothy). Ries et al. made no mention of Roebling, as the town name is more recent, but their Loc. 114 must be essentially the same place. Their brief comment (p. 378) is therefore of significance:

> "At locality 114, due north of Florence station the following section was shown in an old clay pit near the river:

Wind-blown sand	6-8 ft.
Cretaceous sand	4-5 ft.
Tough red and yellow clay	5 ft.
Tough white clay, base not shown	5 ft."

With reference to Owens & Minard's map the three units below the wind-blown sand should be, respectively, the Merchantville, Magothy, and "Raritan" Formations. An earlier report on the clays of New Jersey, that of Cook & Smock (1878, pp. 242-245), gives several different sections taken in claypits in the river bluffs of the same area. The lithologies and thicknesses vary laterally but the formations represented are evidently the same. As the appearance of the dinosaur bone precludes its having come from the dark, lignitic and glauconitic Merchantville, the "Raritan" and the Magothy are left as possible sources. These units and the problems involved in their dating will be discussed in turn.

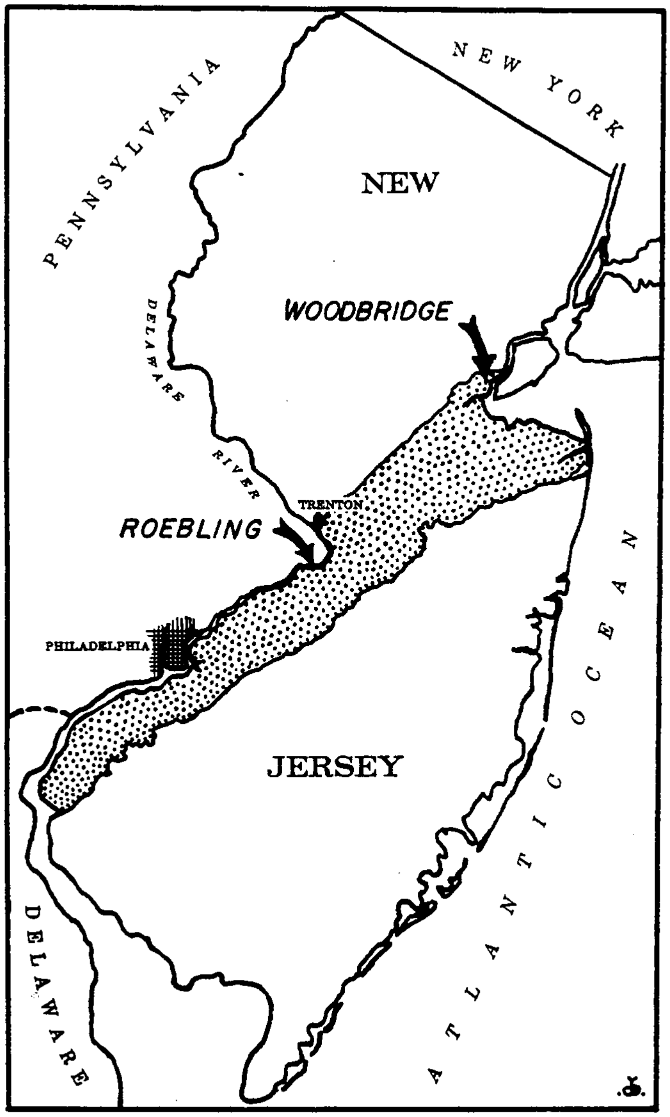

Figure 1. Index map to the Roebling and Woodbridge dinosaur localities. The Cretaceous outcrop is shown in stipple.

My use of quotation marks around "Raritan" expresses caution. The pre-Magothy sediments of the Delaware Valley, which were deposited in the Salisbury Embayment, have traditionally been correlated with the Raritan Formation of northeastern New Jersey, deposited in the Raritan Embayment. In its type area the Raritan has been dated on palynological evidence as Cenomanian and Turonian (Christopher, 1979, 1982). The validity of this traditional correlation, however, is far from firmly established because of the paucity of paleontological evidence in the Delaware Valley area. Owens & Minard (1964) mapped the riparian deposits at Roebling as the Raritan but in a subsequent publication Owens & Sohl (1969, p. 238) concluded that "from Trenton to Salem, N.J., Raritan age sediments are indistinguishable from Lower Cretaceous Potomac Group sediments." Jordan (1983) preferred to assign these deposits to the Potomac Formation, restricting the Raritan Formation to its type area in the Raritan Embayment. On the other hand Metz (1985), working in an area that lies between 10 and 20 miles southwest along the strike of the beds from Roebling, recognized the Raritan Formation and mapped its contact with the overlying Old Bridge Sandstone Member of the Magothy. A position in the upper Potomac would make the dinosaur bone's probable age Cenomanian, while a reaffirmation of the Raritan correlation would make it Cenomanian or Turonian.

Unlike the "Raritan," the Magothy Formation can be traced with confidence into the Delaware Valley from its type area (in Maryland). On palynological evidence (Christopher, 1979, 1982) its age is Coniacian and Santonian.

In summary, the source data available do not permit a choice between the "Raritan" and the Magothy as the source of the dinosaur bone from Roebling. Further biostratigraphic work (palynology in particular) in the Delaware Valley may someday allow us to restrict the time-span involved; i.e., may date those parts of the two formations that crop out along the river at Roebling. For the present, however, we can only say that the bone's age may be as early as Cenomanian or as late as Santonian.

Order SAURISCHIA
Suborder THEROPODA
Infraorder CARNOSAURIA
Family and Genus Indeterminate
(Fig. 2)

Partial metatarsal, cf. *Dryptosaurus* ("Woodbury Fm." *errore*). Baird & Horner (1977).

Carnosauria, indet. ("Campanian" *errore*). Horner (1979, p. 574).

Carnosaur bone. Gallagher (1984, p. 12).

Description

PU 16760 consists of the distal portion of a right second metatarsal, measuring 52 mm in anteroposterior depth and 54 mm in width across the posterior condyles. Its distal end diverges mediad from what remains of the shaft, and is slightly retroverted, so that the articulating surface does not project beyond the anterior surface of the shaft. The fossa for the collateral ligament on the medial side is conical and shallow, while that on the lateral side (next to metarsal III) is bean-shaped and deep, with undercut margins on its posterior and distal sides. On the posterodistal surface a broad sulcus divides the articular area into two condyles, of which the inner or lateral one is slightly larger and extends further distally. On the anterolateral edge of the bone, centered opposite the proximal end of the ligament fossa, stands an elongate boss with a flattened face: this evidently articulated with the underside of a flange extending mediad from the anterior surface of metatarsal III.

At the proximal break the cross-section of the bone is D-shaped, the upright of the D being the planar surface for articulation with metatarsal III; at this point the shaft measures 37.6 mm wide by 37.4 mm deep. The bone is conspicuously hollow, its lumen extending down to a point opposite the upper margin of the medial ligament fossa. Thickness of the shaft wall, measured at the break, ranges from a maximum of 9 mm on the medial side to a minimum of 4 mm on the posterior side.

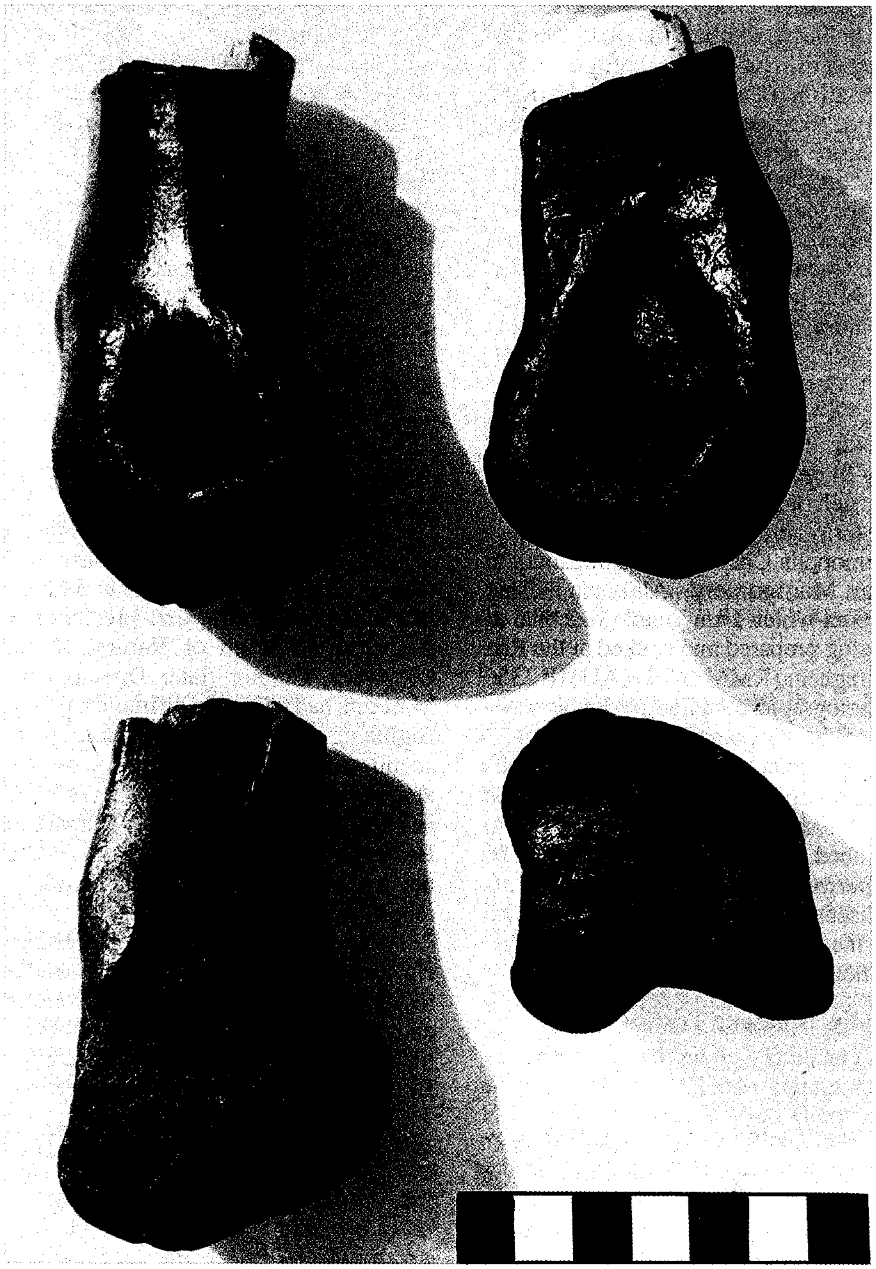

Figure 2. Carnosaur right metatarsal II in medial, lateral, anterior, and distal views (PU 16760, original and casts). Potomac Group or "Raritan" or Magothy Formation (Cenomanian to Santonian) of Roebling, New Jersey. Scale shown in centimeters.

Comparisons

Such carnosaur remains as are known from the Cretaceous of the Atlantic Coastal Plain afford little or no basis for comparison with the specimen in hand. Similarity to the New Jersey carnosaur *Dryptosaurus aquilunguis* is impossible to judge, as only the fourth metatarsal is known in that genus;[2] in any case, *Dryptosaurus* is a specialized, long-limbed theropod and its age—late Maastrichtian—is much younger than that of the Roebling dinosaur.

Fragmentary remains of relatively small carnosaurs from the Black Creek Formation (Campanian) of North Carolina have been described by Baird & Horner (1979), who made inconclusive comparisons with *Dryptosaurus* and *Albertosaurus*. No metatarsals are available. Similarly, no useful comparisons can be made with the fragmentary carnosaur material being collected from the Blufftown Formation (Campanian) of Georgia (Schwimmer, 1986). Both of these occurrences are of course distinctly younger than the specimen from Roebling.

Closer in age—indeed, somewhat older—is the fauna of the Arundel Formation (Aptian) of Maryland. As revised by Ostrom (1970) this scrap-fauna "contains one and perhaps two species of large theropod" based on essentially indeterminate material. The only metatarsals in the collection are ornithomimid, the type of *Ornithomimus affinis* Gilmore. No particular significance can be attached to the fact that the incomplete right pedal phalanx II-1 (USNM 8504), assigned by Marsh (1886) to *Allosaurus medius* and discussed by Gilmore (1920) under the name *Dryptosaurus? medius*, measures 58 mm wide at its proximal end; i.e., is about the right size to articulate with the metatarsal from Roebling.

The one dinosaur with which our specimen shows closest affinities is at present a nondescript: the partial skeleton of a smallish carnosaur from the Demopolis Chalk (Late Campanian to Early Maastrichtian) near Montgomery, Alabama. This skeleton, for information about which I am greatly indebted to James Lamb, is currently being prepared and studied at the Red Mountain Museum in Birmingham (RMM 6670 = AUMP 2366 of Auburn University). Photographs supplied by Lamb show that the second metatarsal of the Alabama dinosaur is slightly larger than the New Jersey specimen and is closely similar, although not identical, to it in configuration. Further discussion of the Alabama carnosaur would be premature here, except to observe that it is a long-limbed genus with what appear to be familial resemblances to *Albertosaurus*. Glimpses like those afforded by the specimens discussed here make it clear that we have much to learn about the distribution, diversity, and systematics of carnosaurian dinosaurs in the Cretaceous.

II. The Woodbridge Dinosaur Trackways

History

In January of 1929 dinosaur footprints were uncovered by workmen (identified in newspapers only as Hungarians) in the Hampton Cutter Clay Works pit at Woodbridge near Perth Amboy in Middlesex County. Apparently these were not the first of their kind, for tracks had been found in the same bed in previous years. Mr. Hampton Cutter reported that his father, William H. Cutter, had recognized a large track "some fifteen years ago" but that it had been broken up during an attempted recovery. The new find, a trackway of four pes imprints, was photographed and diagrammed *in situ* by Meredith E. Johnson of the New Jersey Geological Survey on January 16 (Figs. 3A, 4). Apparently some attempt was made to collect the individual footprints but they disintegrated in the process. Just a year later, in January of 1930, another trackway came to light and was brought to the attention of plant manager Roy E. Anderson. Anderson, a Rutgers graduate with training in geology, promptly notified his former professors about the find. The trackway was photographed (Fig. 3B) and a single footprint was removed on a thick block of clay and donated to the Geological Museum of Rutgers University (Figs. 3B, 6A). Three other tracks were destroyed by workmen according to the Rutgers *Targum* of February 1, 1930.

In the weeks that followed, further lateral excavation of the clay and sand overlying the track-bearing bedding plane brought to light another trackway of four pes imprints; a fifth track was exposed but damaged. Comparison of site photographs leads me to believe that this new occurrence was actually a continuation of the 1929 trackway, although contemporary observers were silent on this point. Be that as it may, the three trackways were evidently made on the same bedding plane by dinosaurs of the same size and species.

Once again Mr. Anderson informed the scientific community of the find. Those who flocked to the scene on March 14 included Drs. Albert O. Hayes, Alfred C. Hawkins, and Helgi Johnson of Rutgers, Fred W. Darby of Yale, New Jersey State Geologist Henry B. Kummel and his assistant (and successor) Meredith E. Johnson, and preparator Charles J. Lang of the American Museum of Natural History. Mrs. Kathyrn B. Greywacz, Curator (later Director) of the New Jersey State Museum, had taken a keen interest in the discovery from the very beginning and kept in close touch with developments, hoping to acquire a specimen for Trenton. Dinosaurs being newsworthy at any time, the discoveries at Woodbridge received extensive newspaper coverage between January and March. Dr. Barnum Brown of the American Museum of Natural History pronounced the tracks to be those of a bipedal, probably carnivorous, dinosaur.

As shown in a series of field photographs in the Rutgers archives as well as newsphotos published on March 16 and 23, four footprints of the latest trackway were individually blocked out and plaster-capped prior to removal. This very sensible methodology had been proposed earlier by Barnum Brown, as Dr. Hayes informed Mrs. Greywacz in a letter of February 3:

> "He advises us that it would be best to remove the sand by suction, such as a vacuum cleaner or a stream of water before the track is removed . . . . In this way it is likely that we shall be able to get

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[2] The metatarsal of *Dryptosaurus aquilunguis* (AMNH 2438) evidently belongs to the holotype individual (ANSP 9995, collected in 1866) although it was acquired years later by Cope, who mentioned it first in 1875 as "lately acquired." It has been described and sketchily illustrated by Huene (1932, p. 63, pl. 3, figs. 9a-b) from a cast in the British Museum.

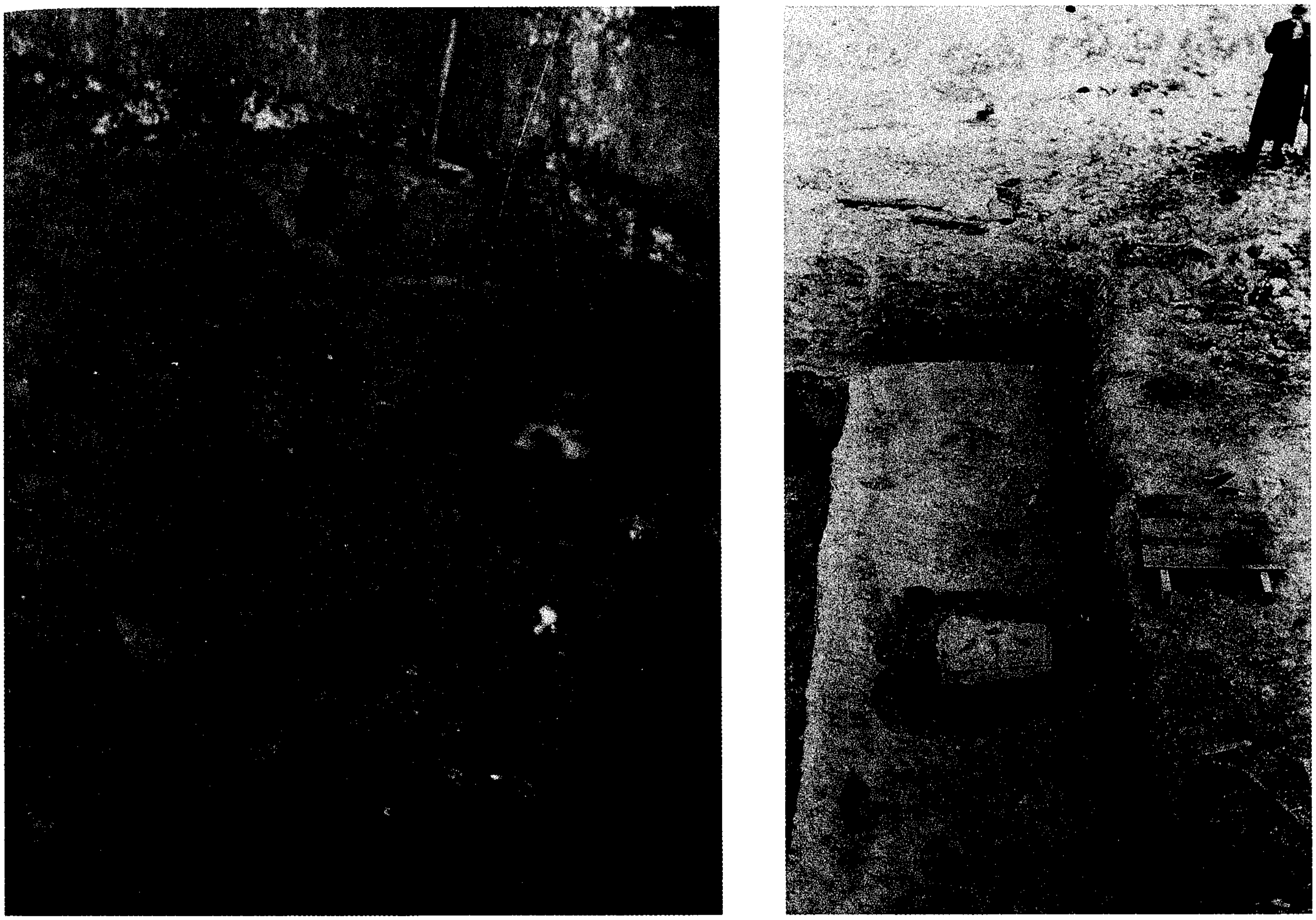

Figure 3. Carnosaur trackways *in situ* in the Hampton Cutter claypit, Woodbridge, New Jersey. A, last two footprints in the January 1929 trackway (New Jersey Geological Survey photograph by Meredith E. Johnson). B, the January 1930 trackway; footprint blocked out is RUGM V/226 (Rutgers University photograph).

> several good originals, and to get fairly perfect impressions, which, due to the soft nature of the clay, may prove to be more valuable for study than the original prints, after the clay has been dried."

Charles Lang, the American Museum's capable technician, managed the work of plastering and excavation so the four footprint blocks could be transported to Rutgers for further treatment and study.

And there the trail ends, both literally and figuratively: the four dinosaur tracks and their plater counterparts have simply disappeared. They were supposed to go to as many different museums—Yale, the American Museum, the New Jersey State Museum, and the Smithsonian Institution were mentioned—but none of these institutions has any record of having received one. Mrs. Graywacz intially proposed an exhibit of four replica tracks in sequence, to be constructed by Charlie Lang for the State Museum, with copies to be made for Yale and the American Museum on a cost-sharing basis. However, Barnum Brown did not think the plan worthwhile for the American Museum, and the space required for such a display in Trenton proved to be prohibitive, so the idea was dropped. In September of 1930 the tracks were still at Rutgers; Dr. Hayes reported that they had dried with less shrinkage-checking than he expected, and Mrs. Greywacz was discussing with Mr. Lang a plan for preparing a single footprint for display; but there the correspondence breaks off. What became of the specimens is a mystery. The only one that can now be located is the single footprint collected in January, which remains on display at the Rutgers Geological Museum.

As Barnum Brown pointed out at a press conference, the Woodbridge find is the first (and remains the only) occurrence of Cretaceous dinosaur tracks in eastern North America. One would think that a unique discovery of this sort would be published promptly in a scientific journal, but such was not the case. Ironically its first formal publication, with photographs, was in a book written by a Biblical fundamentalist to prove that all paleontology and stratigraphy can be attributed to Noah's Flood (Nelson, 1931). And although the occurrence has been mentioned in several scientific publications (e.g., Hayes, 1933, p. 47; Lewis & Kummel, 1940, p. 115; Miller, 1955, p. 904; Wolfe, 1977, p. 100, fig. 4-3; Horner, 1979, p. 573; Weishampel & Weishampel, 1983, p. 60; Gallagher, 1984, p. 12), what follows is the first formal description.

As all the original participants are now dead, the foregoing history of the Woodbridge finds has had to be pieced together

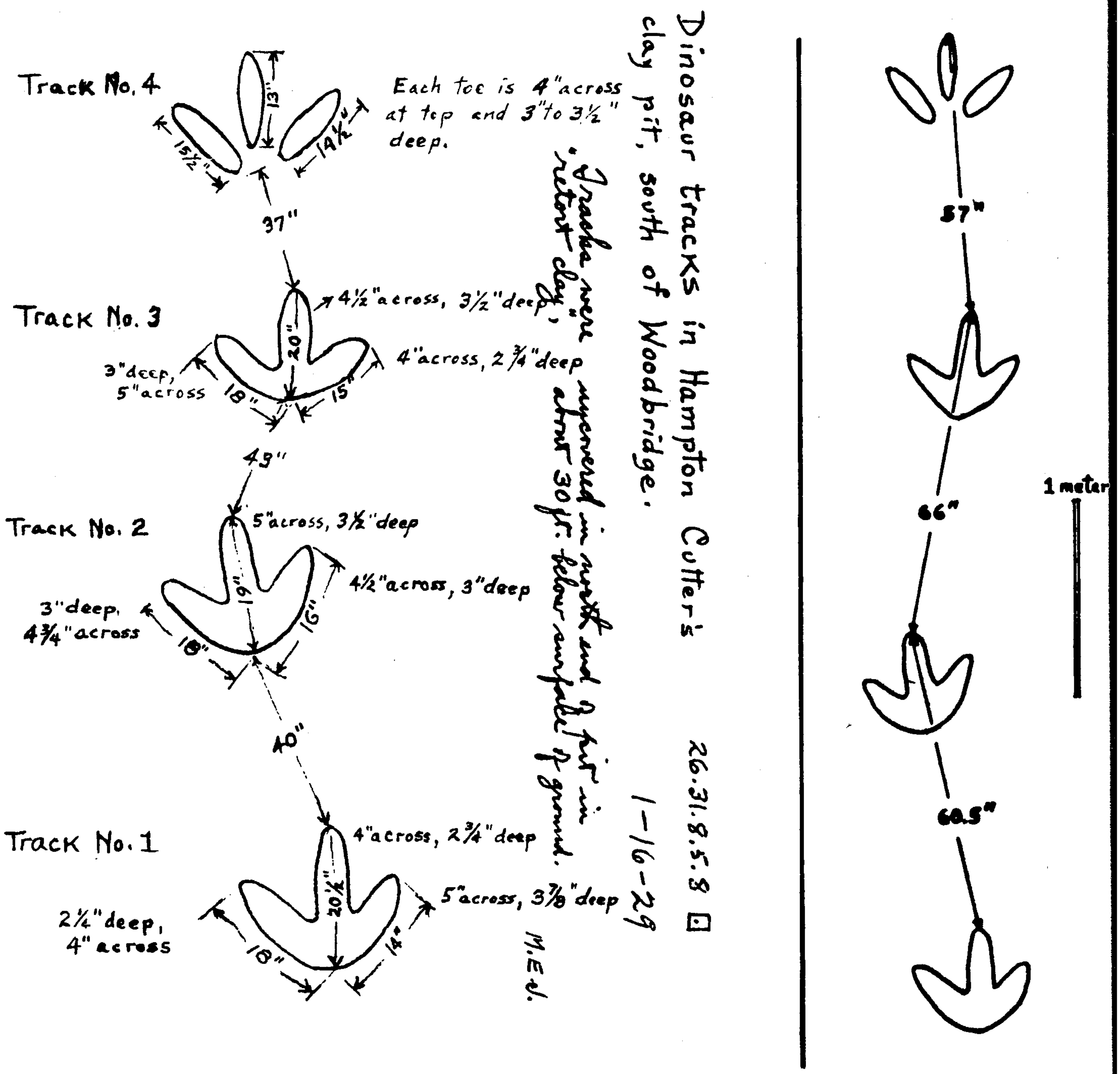

Figure 4. **Left**, trackway diagram in Meredith E. Johnson's field notebook for January 16, 1929 (courtesy of New Jersey Geological Survey). **Right**, the same trackway redrawn to scale. The footprint outlines are diagrammatic; for accurate detail see Figure 6.

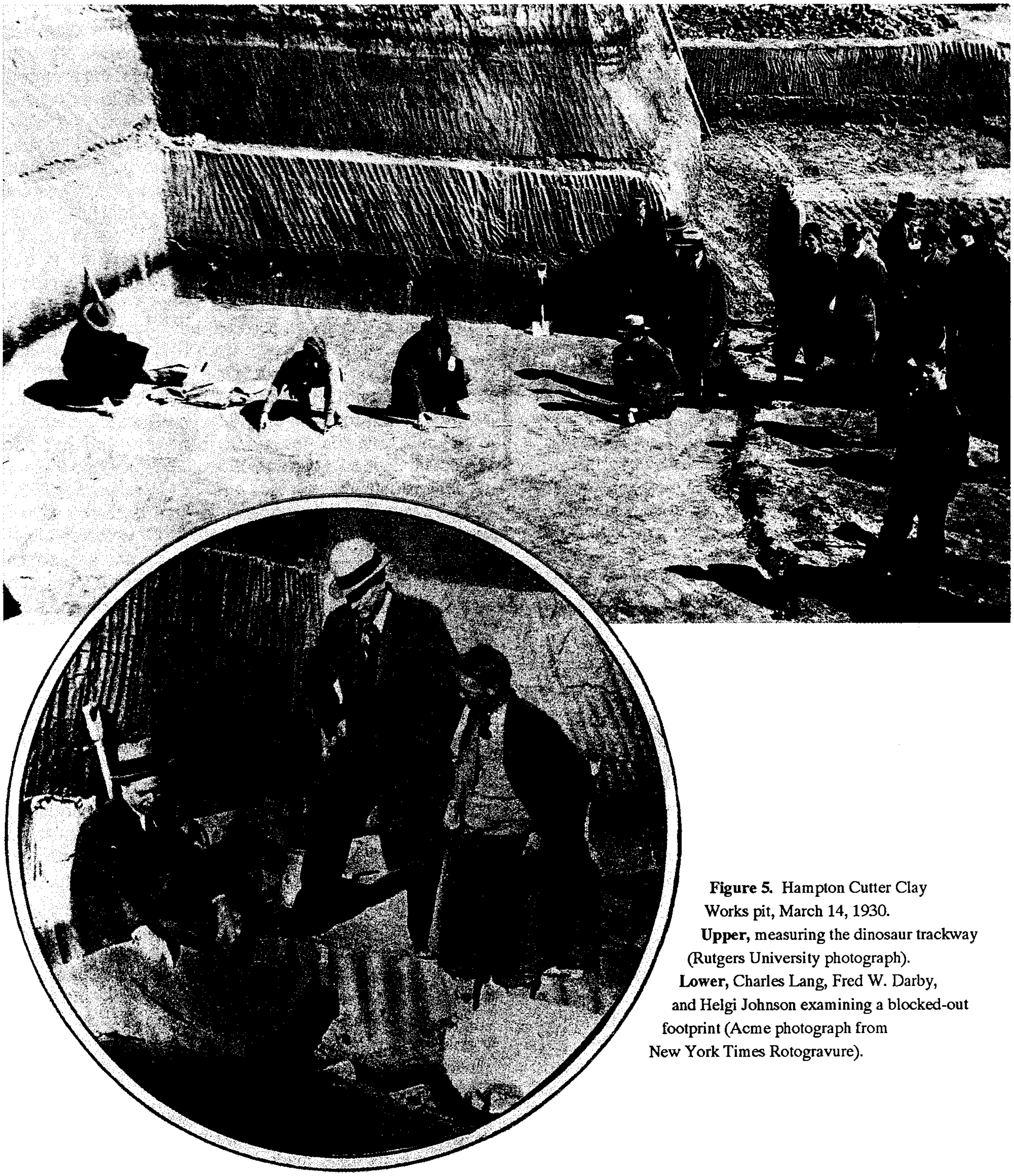

Figure 5. Hampton Cutter Clay Works pit, March 14, 1930. **Upper,** measuring the dinosaur trackway (Rutgers University photograph). **Lower,** Charles Lang, Fred W. Darby, and Helgi Johnson examining a blocked-out footprint (Acme photograph from New York Times Rotogravure).

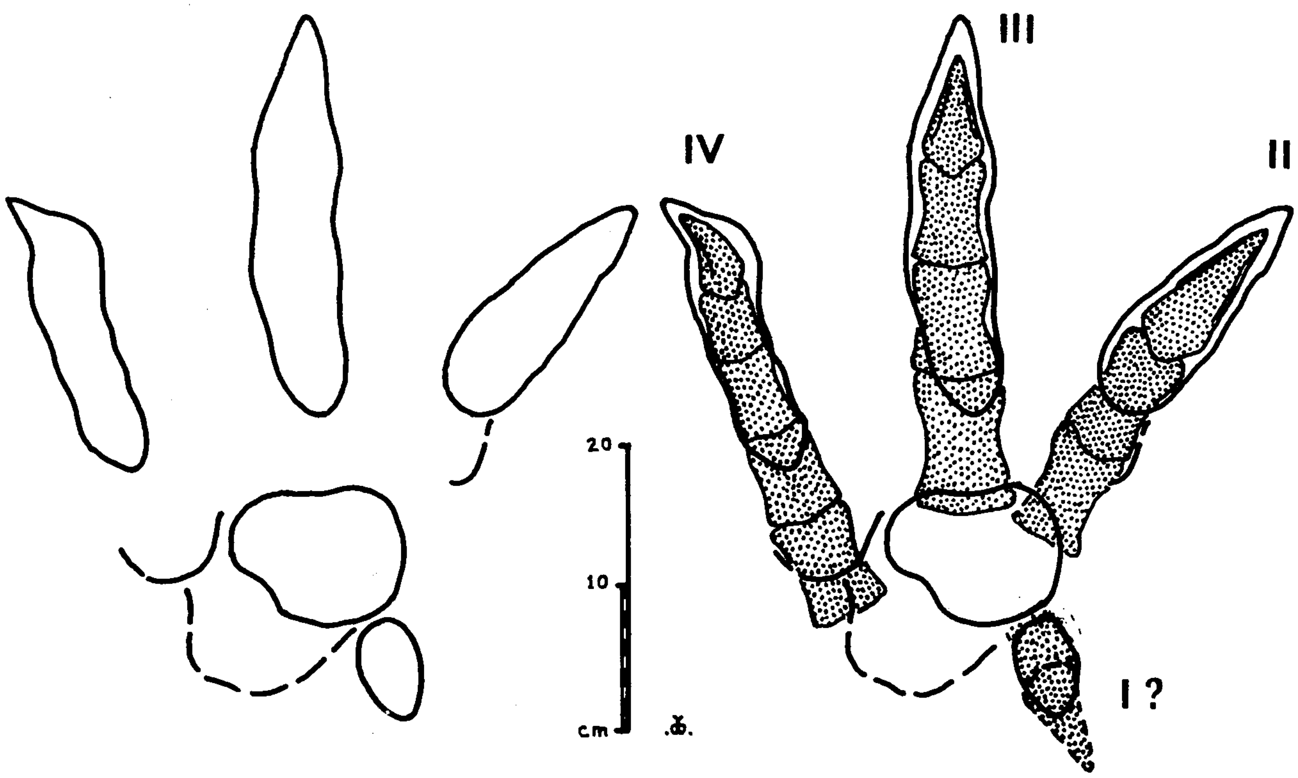

Figure 6. Carnosaur left pes print from Woodbridge, New Jersey, as traced from RUGM V/226 and with pedal skeleton restored. Scale in decimeters and centimeters.

from old documents of varying quality. Meredith Johnson's photographs and diagram of the 1929 trackway were kindly made available by David Harper of the New Jersey Geological Survey. A sheaf of newspaper clippings (not all dated or sourced) and a set of unlabeled field photographs were unearthed in the Rutgers University archives by R. William Selden. An invaluable dossier of Mrs. Greywacz's correspondence about the finds was located in the New Jersey State Museum files by Science Bureau registrar William B. Gallagher. Last and least, the on-site observations of the Reverend Mr. Bryon C. Nelson (brought to my attention by Neal K. Resch) are not without value despite their Diluvialist bias.

Occurrence

The clay pits of W. H. Cutter were mapped by Ries et al. (1904, Localities 29, 30) as lying just south of Woodbridge in Middlesex County, New Jersey, in a tract bounded by Bunn Lane to the north, Perth Amboy Avenue to the east, Spa Spring Road to the south, and King Georges Road to the west; latitude 42° 32' 20" N, longitude 74° 17' W. The site is 3 miles (4.8 km) due north of Sandy Point at the mouth of the Raritan River in Perth Amboy.

The fireclay dug at the Cutter pits is the Woodbridge Clay Member of the Raritan Formation, which is described by Owens & Sohl (1969, p. 239) as "... largely a thin- to thick-bedded sequence of micaceous silts and clays, containing an enormous amount of woody fragments and siderite concretions .... The interbedding of these highly carbonaceous and siderite-rich deposits with deposits containing open-marine fossils indicates the Woodbridge was deposited in close proximity to the sea .... It is likely that the thick accumulation of carbonaceous-rich beds of the Woodbridge were deposited in marginal-marine mangrove-type swamps." As the palynomorphs of this unit belong to the *Complexiopollis-Atlantopollis* Assemblage Zone, Christopher (1979, 1982) has assigned it to the Middle (or possibly Late) Cenomanian Stage.

At the same time that the first footprint was being collected for Rutgers, a lignitic layer in the overlying clay yielded a fossil plant specimen that was identified by Rutgers botanist Mintin A. Chrysler (1931) as the apical region of a cycadeoid trunk showing the leaf-bases. Chrysler (1932) later described it in detail as a new species, *Cycadeoidea peridermalis*. A parasitic fungus infecting the leaf-bases was named *Xylomites cycadeoideae* by Chrylser & Haenseler (1936).

The most remarkable feature of the Woodbridge trackways is, of course, their preservation in unconsolidated sediments. The footprints were made in damp clay and were almost immediately filled by an overwash of alluvial sand. Neither sediment became indurated subsequently, so that the beds could be dug with the spade. The preservation of 90-million-year-old footprints under these exceptional circumstances is as unexpected as it is fortunate.

Description of Trackway

The trackway of January 1929 was diagrammed and measured by Meredith Johnson as shown in Figure 4. No measurements are recorded for the 1930 trackways, and most of the photographs of them provide no metric information. Lacking scaffolding or a derrick, the scientists who visted the site were unable to take photographs normal to the bedding plane, from which one could calculate the stride, left-to-right pace, pace angulation, and orientation of the footprints with respect to the midline of the trackway. One Rutgers photo of the March trackway (Fig. 5, upper), however, was taken at right angles to the direction of movement and shows a carpenter's folding ruler being held between the first two footprints. Although the markings on the rule are illegible, its 6-inch segments can be made out under magnification and the pace length can be read as approximately 64 inches (162 cm).

The 1929 trackway (which may well be a more proximal segment of the March 1930 sequence) has been redrawn to scale from Johnson's dimensions in Figure 4. Pace lengths of 154, 168, and 145 cm (for a mean of 156 cm) and stride lengths of 353 and 348 cm (for a mean of 350 cm) can be scaled from the diagram. Pace angles of 157° and 166° are indicated and the latter figure can be confirmed by measurement on Figure 3A. Obviously the trackway was quite narrow and nearly linear, with its midline passing through the bases of digits II, and with the central digit III diverging outward only slightly from the direction of movement.

The footprint in Figure 6 was traced from the specimen preserved at Rutgers. Except for the rather wide divarication of the lateral digits II and IV, who axes meet at an angle of about 60°, and the relative shortness of digit III, it is a typical carnosaur track. Lateral swellings and sole-pads indicate the positions of the inter-phalangeal joints, giving the expected phalangeal formula of 3-4-5 for the principal toes. The claws were acute. A deep basin at the base of the central digit was made by a sole-pad underlying the third metatarso-phalangeal joint. Posteromedial to this is a shallow oval depression that may have been made by a backward-turned digit I. Additional material would be necessary to confirm its identity, but its position at least is correct for a hallux imprint.

Comparisons

Dinosaur tracks that are closely comparable to those from Woodbridge have been described from Lower Cretaceous strata in several parts of the world. Earliest in point of publication are those from the Wealden of Germany, described by Ballerstedt (1905) and subsequently named *Bueckeburgichnus maximus* by O. Kuhn (1958)--see Figure 7A. [The original spelling *Buckeburgichnus* is subject to automatic emendation. "*Megalosauripus*" Lessertisseur (1955), a *nomen nudum* based on Ballerstedt's material, is not to be confused with *Megalosauropus* Colbert & Merrilees, mentioned below, although they are probably synonymous.] The heel and hallux imprints that are so conspicuous in the German footprint are doubtless the result of exceptionally deep impression, and their absence from shallower tracks should not be interpreted as a significant morphological difference between the trackmakers.

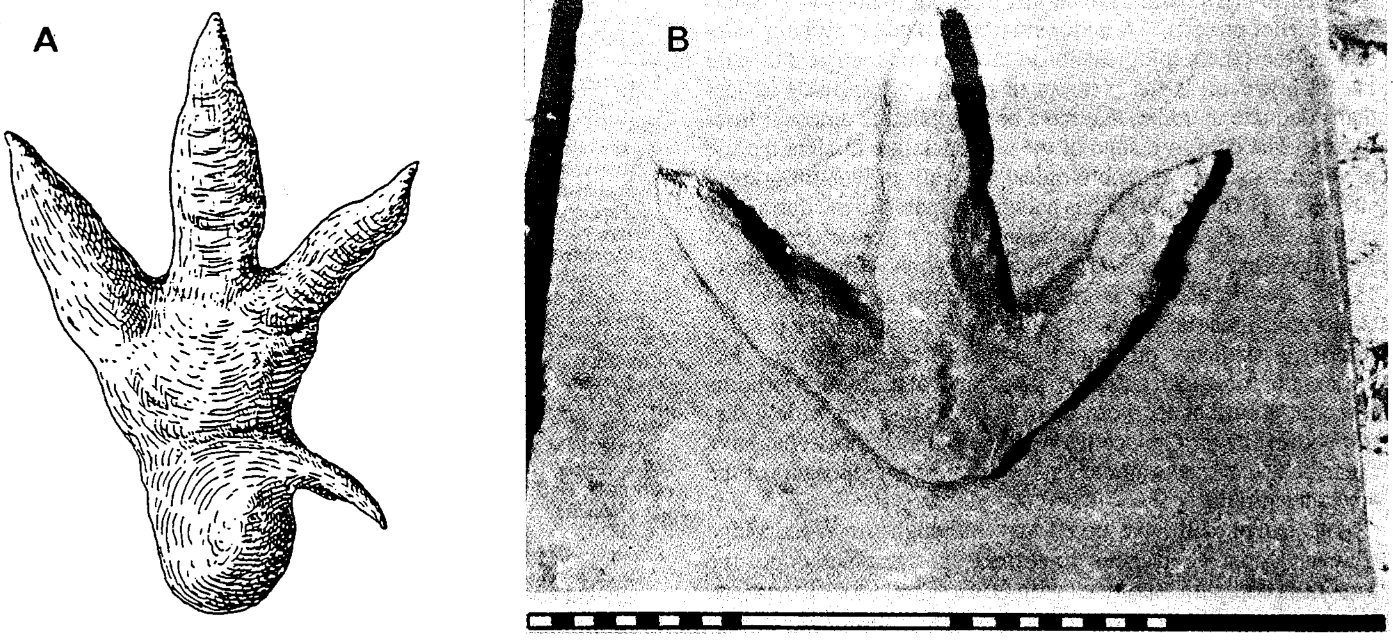

Figure 7. A, *Bueckeburgichnus maximus* from the Wealden near Buckeburg, Niedersachsen, Germany (from Abel, 1935). Overall length is 71 cm. *B, Megalosauropus broomensis*, a topotype footprint from the Lower Cretaceous Broome Sandstone at Gantheaume Point near Broome, Western Australia. Cement cast (WAM G10328) made by the discoverer, Mr. Walter Jones, in 1945 (Western Australian Museum photograph). Note that the angle of view is not quite perpendicular to the bedding plane, causing slight distortion. Scale in decimeters and centimeters. Both A and B are natural casts of right pes imprints and thus appear in reverse as if lefts.

The ichnogenus *Megalosauropus* (type species *M. broomensis*) was based by Colbert & Merrilees (1967) on trackways exposed at low tide on the beach at Gantheaume Point near Broome, Western Australia. The source formation is the Broome Sandstone, which has been dated as Lower Cretaceous on paleobotanical evidence. This occurrence had been reported earlier by Ludwig Glauert (1952) of the Western Australian Museum. Neither publication illustrated the footprints on a large enough scale that details of their morphology could be made out, and the sketch by Merrilees of one track that has been published by Haubold (1971, Abb. 48.1) is unhelpful. To amplify the record I offer here (Fig. 7B) a photograph that was kindly supplied by Mr. Glauert before his death in 1963.

Equally close comparisons can be made with *Irenesauripus* from the Gething Formation (Barremian to Aptian) of the Peace River Canyon in British Columbia (Sternberg, 1932; Currie & Sarjeant, 1979); with the carnosaur tracks (*Eubrontes*? *glenrosensis* Shuler, 1935) found in association with sauropod trackways in the Glen Rose Sandstone (Aptian to Albian) of Texas, discussed in Bird (1985) and monographed by Farlow (1987); and with tracks named *Satapliasaurus* by Gabuniya (1951) from the Lower Cretaceous of Georgia, U.S.S.R. Similar tracks from the Cenomanian of Israel (Avnimelech, 1966) and Spain (Casanovas et al., 1984) might also be mentioned, but a comprehensive survey of occurrences is beyond the scope of this paper.

So far as I can tell, the footprints just listed all conform to a single morphotype for which a single ichnogeneric name should suffice. Unfortunately it seems to be customary for describers of fossil footprints to toss out new names like confetti at a Mardi Gras, seldom justifying their purportedly new taxa by differential diagnoses. As a result the nomenclature of Cretaceous footprints is (if possible) even more chaotic than that of tracks from earlier periods. "A major stumbling block to full exploitation of the paleobiological information contained in dinosaur tracks, however, is the plethora of names, often based on less than adequate material, that have been applied to dinosaur trace fossils. The confused state of the nomenclature hinders the use of these fossils in paleobiological as well as biostratigraphic studies.... This problem has become palpable to me during my own studies of a classic ichnofauna ... from Lower Cretaceous rocks of Texas" (James O. Farlow, personal communication, 1987). As Dr. Farlow is currently attempting to sort out the Cretaceous ichnotaxa and determine their names on the basis of priority, I shall not presume to duplicate his work here. For present purposes let it suffice to point out that dinosaur footprints essentially similar to those from Woodbridge are widely distributed in Lower Cretaceous rocks. All the authors who have described such tracks agree that they represent carnosaurs of the "megalosaurian" type.

The reader will have noted that, although the Woodbridge Clay is Upper Cretaceous in formal stratigraphic usage, the foregoing comparisons are all with Lower Cretaceous footprints. No paradox or local anomaly is involved, for as Lockley (in press) points out, in the worldwide perspective of dinosaurian ichnology the Cenomanian is faunally allied with the Lower Cretaceous. The subsequent Turonian, Coniacian, and Santonian Stages are apparently barren of footprints, and substantial changes in the composition of the dinosaurian fauna had occurred by the time the ichnological record resumes in the Campanian.

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